IN THE UNITED STATES PATENT & TRADEMARK OFFICE

In re Patent application of	:	
Jyoti Kiron BHARDWAJ et al.	:	Group Art Unit: 1763
Serial No. 09/601,958	:	Examiner: Parviz Hassanzadeh
Filed August 10, 2000	:	

PLASMA PROCESSING APPARATUS

REQUEST FOR RECONSIDERATION

U.S. Patent and Trademark Office
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Crystal Plaza Two, Lobby, Room 1B03
Arlington, VA 22202

Sir:

This is in response to the Office Action dated May 30, 2003, the period for response having been extended by a Petition for Extension of Time submitted concurrently herewith.

Claims 1, 4 and 6 were rejected under 35 U.S.C. ¶103 as being unpatentable over Bhardwaj et al. (EP 0822582 A2) in view of Amemiya et al (EP 0488393 A2) for the reasons stated at pages 2-4 of the Office Action. Claims 1, 4, 6-9, 12-15 and 21 were rejected under 35 U.S.C. ¶103 as being unpatentable over Bhardwaj et al. in view of Ohkawa et al. (EP 0831516 A2), taken alone or in combination with Kin (JP 61-39521), Ribeiro (US 4,769,101) or Maeno et al. (US 6,060,836) for the reasons stated at pages 4-7 of the Office Action. However, Applicants respectfully contend that the now-pending claims define over the cited references, and in view of the following representations, reconsideration of the rejections under 35 U.S.C. ¶103 is requested.

As Applicants understand the rejections, the Examiner contends that it would be obvious to use the ion traps allegedly taught by Ameniya et al. and Ohkawa et al. in the process of Bhardwaj et al. Applicants disagree. As explained below, the use of an ion trap or ion attenuator would not have been obvious to someone skilled in the art intending to operate a switched etch process such as that of Bhardwaj et al.

The switched etch process in its basic form requires the sequence of etching of the substrate and passivation of the exposed surfaces, to be repeated many times in order to manufacture the required feature. In each cycle of etch and passivation, the following sequence of actions occurs:

> In the first part of the etch step, ions from the plasma are accelerated towards the substrate and impact the bottom of the trenches or other features and other horizontal surfaces, removing passivating material that has previously been deposited. The directionality of the ions ensures that passivating material is not removed from the sidewalls of the trench.
>
> In the second part of the etch step the material exposed at the bottom of the trench is etched. In the case of silicon this etching is almost entirely isotropic by neutral radicals with very little assistance from the ion flux.
>
> The passivation step then relies on the deposition of a polymer or other suitable material on all surfaces, requiring no or little ion assistance.

From the above it can be appreciated that it is important that some ions are accelerated to the substrate during the first part of the etch step, therefore, the complete trapping of ions from the plasma is not desirable for the switched etch process. This is unlike isotropic etching/photo-resist removal described in Amemiya et al. For example, at column 3, lines 6-9, Amemiya et al. states that "Therefore only radicals are allowed to act on the substrate to be treated, so

that the isotropic etching can be carried out at a higher rate without damaging the substrate by ions". Likewise, claim 1 of Amemiya et al. recites "ion trap means (38) arranged between the plasma generating section (25) and the substrate treating section (24) to trop ions in the plasma so as to send neutral radicals into the substrate treating section (24)". The apparatus of Amemiya et al. in fact makes no provision for the acceleration of ions to the substrate, with no suitable power supply connected to the substrate support Fig. 2. It would therefore not be obvious to incorporate the ion trap means of Amemiya et al. in the process of Bhardwaj et al. Similar comments apply in the case of Ohkawa et al.

Prior to the effective filing date of the present application, plasma processing equipment manufacturers manufactured plasma processing equipment to carry out the switched etch process very effectively, with no requirement for any form of ion trop or ion attenuator. Users of the equipment were able to achieve very precise etching of high aspect ratio features operating the switched etch process. Most equipment designed for the switched etch process operated with up to 1kW of RF power used to create the plasma. The relative numbers of ions and neutral radicals produced in the plasma were close to ideal for carrying out the different stages of the etch process, with no need for modification. It was recognized that ions did not need to be accelerated significantly to the substrate during the passivation step or in some cases the second part of the etch step. So removing the substrate bias at these times helped to reduce the erosion of the mask.

As the switched etch process became well established, a number of applications required increased etch rates. One way of achieving an increased etch rate is to increase the power fed into the plasma, thereby increasing the numbers of ions and neutral radicals. Unfortunately experimental work indicated that while the number of ions increased reasonably linearly with power fed into the plasma, the number of neutral radicals increased more

slowly. There was therefore a need to modify the ratio of ions to neutral radicals produced by the plasma, which had not been recognized prior to the requirement for increased etch rates.

It is well know by plasma scientists that electron motion may be affected by magnetic fields of low to medium strengths, and that positive ions will follow the motion of the electrons, because otherwise large electric fields will be created in the plasma. Ohkawa et al. state column 1 lines 35-39 that, "Further, it is known that a magnetic field has a significant effect upon free electrons transport in the plasma. Specifically, plasma flux in a direction perpendicular to the magnetic field is significantly inhibited".

It is equally well known by plasma scientists that placement of an object in a plasma will result in electron – ion recombination on the surface of the object, thereby depleting the number of ion – electron pairs in the plasma, while having only a small effect on neutral radical numbers.

With regard to the installation of an ion trap or ion attenuator in the equipment designed for the switched etch process, there was no requirement for such a feature until the power fed to the plasma was increased. It was only then that it was recognized that the ratio of ions to neutral radicals was no longer ideal. The inventive aspects of the present invention reside in recognizing that a problem has come into existence, considering techniques, and then applying them to the specific problem in such a way as to solve or reduce the problem.

An ion trop or ion attenuator that stopped almost all ions reaching the substrate during all the process cycle would not be suitable for use for the switched etch process. The invention therefore involves choice of appropriate ion – electron pair loss areas, or static magnetic fields, or time varying magnetic fields such as to ensure that sufficient positive ions are present above the substrate to be accelerated to the substrate during the first part of the etch step. Without positive ions accelerated to the substrate in this part of the cycle the anisotropic etching would not take place.

One of ordinary skill would not be motivated to simply incorporate the ion traps allegedly taught by Ameniya et al. and Ohkawa et al. in the process of Bhardwaj et al.

For at least the reasons stated above, Applicants respectfully contend that the present claims define over the cited reference, taken individually or in combination.

No other issues remaining, reconsideration and favorable action upon the claims now pending in the application are requested.

Respectfully submitted,

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